Australian Government

IP Australia

Letters patent

Patents Act 1990

No:
2002249788

Standard Patent

I, Fatima Beattie, the Commissioner of Patents, grant a Standard Patent with the following particulars:

Name and Address of Patentee(s):

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Title of Invention:

High performance micro-filter and splitter apparatus

Term of Letters Patent:

Twenty years from 14 November 2001

Priority Details:

Number	Date	Filed with

COMMONWEALTH OF AUSTRALIA
AUSTRALIA
PATENT OFFICE

Dated this 24th day of February 2005

Fatima Beattie
Commissioner of Patents

(12) STANDARD PATENT (11) Application No. AU 2002249788 B2
(19) AUSTRALIAN PATENT OFFICE

(54) Title
High performance micro-filter and splitter apparatus

(51)[7] International Patent Classification(s)
H04M 011/06 H04L 027/00

(21) Application No: 2002249788 (22) Date of Filing: 2001.11.14

(87) WIPO No: WO03/045043

(43) Publication Date: 2003.06.10
(43) Publication Journal Date: 2003.08.21
(44) Accepted Journal Date: 2004.11.11

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(56) Related Art
EP 677938
EP 1076447

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 May 2003 (30.05.2003)

PCT

(10) International Publication Number
WO 03/045043 A1

(51) International Patent Classification[7]: H04M 11/06, H04L 27/00

(21) International Application Number: PCT/US01/45568

(22) International Filing Date: 14 November 2001 (14.11.2001)

(25) Filing Language: English

(26) Publication Language: English

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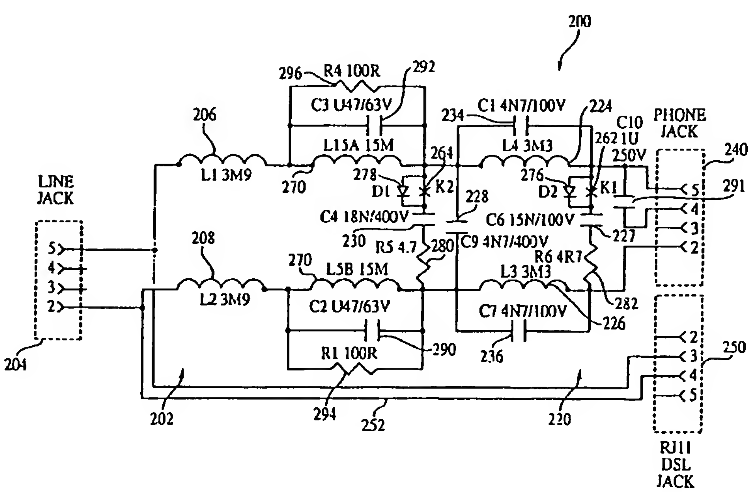
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: HIGH PERFORMANCE MICRO-FILTER AND SPLITTER APPARATUS



(57) Abstract: Apparatus for conditioning and splitting telecommunications signals such as digital subscriber line (DSL) signals with improved stop band and return loss performance. In one aspect, the invention comprises an improved circuit having filter, impedance correction, and dynamic switching functionality suitable for more stringent application requirements (such as Europe). In one embodiment, the filter comprises a fourth-order elliptical filter coupled to an RLC impedance correction network. Dynamic switching is accomplished via a plurality of switch elements based on, e.g., filter current. In a second embodiment, a non-dynamic splitter with impedance correction and filter circuit is disclosed. Subscriber-end systems employing the foregoing signal conditioning and splitter circuits are also described.

WO 03/045043 A1

HIGH PERFORMANCE MICRO-FILTER AND SPLITTER APPARATUS

Background of the Invention

1. Field of the Invention

The present invention relates generally to electronics used in telecommunications applications, and particularly to an improved filter and splitter apparatus and methods for use in a digital subscriber line (DSL) or similar telecommunications system.

2. Description of Related Technology

Today, Asymmetrical Digital Subscriber Line (ADSL) installations are mostly what is known as "self-install", or specifically where the subscriber installs a micro-filter or in-line phone filters on each telephone to isolate the phones (including faxes, answering machines, etc.) from the line and the ADSL signal path. Fig. 1 illustrates a typical installation of such in-line filters.

The self-installable micro-filter is a challenging design, largely because it must have sufficient stop band in the DSL band to protect and preserve DSL performance, but at the same time should also have negligible effect on the voice band performance.

Fig. 1a illustrates a typical prior art in-line filter configuration used in DSL applications. Such prior art filter designs, however, often do not satisfy some of the telecom customer's requirements for both return loss and DSL stop band. One significant problem is that the total capacitance required for the DSL stop band requirements also produce excessive side tone in the upper band of the telephones, a highly undesirable result. Furthermore, the return loss problem becomes worse as more micro-filters are added for each of the subscriber's phones.

United Kingdom (UK) and European filter circuit requirements are more stringent. One major challenge in this regard is providing the 30 KHz stop band while providing the very high voice band return loss.

Based on the foregoing, an improved apparatus and method for filtering digital subscriber line (DSL) signals is needed. Such improved apparatus and methods would (i) be readily installed and implemented by the subscriber, (ii) make use of existing telecommunications and/or power line infrastructure, (iii) provide enhanced stop band and return loss performance with no penalty on other aspects of circuit performance, and (iv) be compatible with and/or adaptable to a number of different applications and prevailing

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telecommunications specifications, thereby providing, *inter alia*, maximum manufacturing flexibility.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

Summary of the Invention

At least preferred embodiments of the present invention satisfy the aforementioned needs by providing an improved digital subscriber line communications filter and splitter apparatus, and method of operating the same.

According to a first aspect of the invention, there is provided a telecommunications signal conditioning apparatus adapted to provide both enhanced stop band attenuation and enhanced voice band return loss performance, comprising:

first terminals adapted to interface with a first telecommunications line, said telecommunications line being adapted to carry signals having DSL and voice band components;

second terminals adapted to interface with an extension device;

impedance correction apparatus disposed electrically between said first and second terminals and adapted to alter return loss with respect to said voice band component of said signals;

signal filter apparatus in electrical communication with said first and second terminals and said impedance correction apparatus and comprising dynamic switching apparatus adapted to selectively alter the configuration of said signal filter apparatus so as to increase the capacitance of said filter apparatus, said increase in capacitance providing at least in part said enhanced stop band attenuation.

According to a second aspect of the invention, there is provided a method of conditioning a digital subscriber line (DSL) signal flowing through filter circuit so as to provide both at least predetermined minimum levels of stop band attenuation above a predetermined frequency, and voice band return loss greater than a predetermined minimum value, comprising:

filtering at least a portion of said signal;

switching at least a portion of said filter circuit, said act of switching selectively altering the configuration of said filter circuit so as to increase the capacitance thereof,

said increase in capacitance providing at least in part said minimum level of stop band attenuation stop band attenuation; and

selectively adjusting the impedance of said circuit to provide said return loss greater than said minimum value.

According to a third aspect of the invention, there is provided a signal splitter apparatus for use with telecommunications signals having at least first and second signal components, comprising:

filter apparatus having a plurality of inductors and being adapted to filter said telecommunications signals; and

impedance correction tank circuits in electrical communication with said input filter apparatus and adapted to control the return loss associated with said second component of said signals;

wherein at least first and second ones of said plurality of inductors are disposed before and after, respectively, said impedance correction tank circuits, within said splitter apparatus.

According to a fourth aspect of the invention, there is provided a telecommunications subscriber-side system, comprising:

a telecommunications line adapted to carry signals having first and second signal components;

a plurality of signal conditioning circuits operatively coupled to said telecommunications line, each of said signal conditioning circuits having:

a filter circuit;

an impedance correction circuit adapted to provide increased return loss with respect to said second signal component; and

a dynamic switching circuit adapted to provide increased stop band loss attenuation with respect to said first component at least by increasing the capacitance associated with said filter circuit; and

a plurality of extension devices operatively coupled to said signal conditioning circuits.

According to a fifth aspect of the invention, there is provided a telecommunications subscriber-side system, comprising:

a telecommunications line adapted to carry signals having first and second signal components;

a plurality of signal splitter circuits operatively coupled to said telecommunications line, each of said splitter circuits having:

a greater-than-second-order filter circuit comprising both an input section and an output section;

an impedance correction circuit disposed electrically between said input and output sections and adapted to control the return loss with respect to said second signal component; and

a plurality of extension devices operatively coupled to said signal conditioning circuits, said extension devices operating on-hook at a low capacitance level relative to another of said extension devices operating at a higher capacitance when off-hook, said higher capacitance providing a minimum required stop band attenuation above a certain frequency.

According to a sixth aspect of the invention, there is provided a telecommunications signal conditioning apparatus, comprising:

first terminals adapted to interface with a first telecommunications line, said telecommunications line being adapted to carry signals having first and second components;

second terminals adapted to interface with an extension device; and

impedance correction apparatus in electrical communication with said first terminals and adapted to enhance return loss with respect to said second component of said signals, said impedance correction apparatus comprising:

first and second inductors disposed in a dual inductor device configuration;

a plurality of capacitances and resistances disposed in electrical parallel with said first and second inductors; and

a reed switch operatively coupled to said inductor device;

wherein said dual inductor is adapted to both (i) drive said reed switch during off-hook conditions, and (ii) form a differential resonance impedance in series with the line input, said resistances being configured to limit the maximum insertion loss associated with said signal conditioning apparatus.

According to a seventh aspect of the invention, there is provided a telecommunications signal conditioning apparatus adapted to provide both enhanced stop band attenuation and enhanced voice band return loss performance, comprising:

first terminals adapted to interface with a first telecommunications line, said telecommunications line being adapted to carry signals having DSL and voice band components;

second terminals adapted to interface with an extension device;

signal filter apparatus comprising:

first inductors in electrical communication with respective ones of said first terminals;

second inductors in electrical communication with respective ones of said second terminals; and

dynamic switching apparatus disposed electrically between said first and second inductors and adapted to selectively alter the configuration of said signal filter apparatus so as to increase the capacitance of said filter apparatus, said increase in capacitance providing at least in part said enhanced stop band attenuation; and

at least one impedance correction tank circuit disposed electrically between said first and second inductors and adapted to alter return loss with respect to said voice band component of said signals.

In an embodiment of the invention, an improved in-line signal filter apparatus for use in telecommunications applications is disclosed. In one embodiment, the application comprises an asymmetric digital subscriber line (ADSL) and associated Telco wiring having a plurality of extension jacks, and the apparatus comprises one or more dynamic filter circuits interposed between the extension jacks (e.g., wall jack) and the subscriber's associated extension devices (telephone, answering machine, etc.). Each filter circuit may comprise an input portion, impedance correction portion, and dynamic response portion. In one exemplary variant, the circuit comprises a fourth order filter with an input section comprising a plurality of series inductors, and an impedance correction portion comprising a plurality of parallel RLC networks disposed in parallel with the inductors. Dynamic circuit elements (e.g., reed switches which are magnetically coupled to one or more of the inductors in the circuit) may be used to vary the configuration, and therefore response, of the circuit when the extension device state changes, such as in going from an "on hook" to "off hook" condition. For example, when the extension device goes off hook, the associated filter circuit dynamically increases its capacitance in relation to the other on hook extension devices, thereby providing enhanced signal performance. Additionally, to protect the dynamic circuit elements from ringing voltage, protective elements (e.g., Zener diodes or varistors) are employed in the circuit to clamp the voltage to an acceptable level.

In another embodiment of the invention, the foregoing circuit is adapted to function as an improved signal splitter device for use in applications having master jack wiring. The splitter device includes the aforementioned input and impedance correction portions, yet without the dynamic portion of the circuit. The impedance correction portion, coupled with the higher order (e.g., fourth order elliptical) filter, provides, in at

least preferred embodiments of the invention, enhanced splitter performance as compared to existing prior art designs.

In another embodiment of the invention, an improved method of conditioning telecommunications signals using a circuit such as that previously referenced is disclosed. In one embodiment, the method generally comprises: providing telecommunications signals having both first and second components; filtering at least a portion of the signals; and dynamically varying the capacitance of the circuit based at least in part on the magnitude of current flowing through at least a portion of the circuit. In another embodiment, the method further comprises selectively adjusting the impedance of the circuit to alter the return loss of the signals, thereby enhancing circuit (and system) performance.

In another embodiment of the invention, a telecommunications system architecture incorporating the improved filter or splitter apparatus previously described is disclosed. The system may comprise (i) a telecommunications line having a plurality of extensions within the subscriber's site, and carrying voice and DSL components; (ii) a plurality of filter or sputter circuits interconnected with respective ones of the extensions; and (iii) a plurality of extension devices (e.g., telephones, answering machines, etc.) connected to respective ones of the filter circuits.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

Brief Description of the Drawings.

The features, and advantages of the invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings, wherein:

Fig. 1 is a block diagram of a typical prior art ADSL installation in a home or small business environment, including prior art micro-filters installed on multiple phone extensions. Fig. 1 a is a schematic of the prior art DSL micro-filters shown in Fig. 1.

Fig. 2 is a schematic of one exemplary embodiment of the dynamic micro-filter circuit of the present invention, adapted for use with a multi-terminal telecommunications jack and extension device.

Fig. 2a is a top plan view of a first embodiment of a dual winding inductor/reed switch device for use in the filter circuit of Fig. 2.

Fig. 2b is a side elevational view of the dual winding device of Fig. 2a.

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Fig. 2c is an end view of a second embodiment of the dual winding inductor/reed switch device for use in the circuit of Fig. 2.

Fig. 2d is a side elevational view of the dual winding inductor device of Fig. 2c.

Fig. 3 is a schematic of a second embodiment of the filter circuit of the invention, adapted for use as a splitter in applications having with master jack wiring.

Figs. 4a - 4c are top, front, and rear plan views of one exemplary embodiment of a filter housing used in conjunction with the filter circuits of Figs. 2 and 3.

the description continues on page 4

Fig. 5 is a block diagram illustrating one exemplary embodiment of the telecommunications system architecture of the invention, including dynamic filter circuits.

Detailed Description of the Preferred Embodiment

Reference is now made to the drawings wherein like numerals refer to like parts throughout.

As used herein, the term "signal conditioning" or "conditioning" shall be understood to include, but not be limited to, signal voltage transformation, filtering and noise mitigation, signal splitting, impedance control and correction, current limiting, capacitance control, and time delay.

It is noted that while portions of the following description is cast in terms of RJ-type connectors and associated modular plugs of the type well known in the telecommunications art, the present invention may be used in conjunction with any number of different connector types. Accordingly, the following discussion is merely exemplary of the broader concepts.

Additionally, the terms "site" and "subscriber's site" as used herein shall include any location (or group of locations) having telecommunications line service provided thereto, including without limitation residential houses, apartments, offices, and businesses.

Lastly, as used herein, the term "extension device" is meant to include any type of telecommunications device compatible with use on existing telecommunications lines, including without limitation conventional telephones, answering machines, facsimile machines, wireless or satellite receivers, and multi-line phones.

Overview

The present invention solves the problems of inadequate stop band and voice band performance on telecommunications lines by advantageously providing (i) a "dynamic" filter configuration which can change states dependent on the operating condition of the associated extension devices; and (ii) an impedance correction circuit which provides, *inter alia*, enhanced return loss performance. Specifically, in the case of a telecommunications line having voice and DSL signal components, when one of the phones on the line goes "off hook" (typically only one of the phones are off hook at any one time), the dynamic circuitry of the off hook filter increases its capacitance, while all the other "on hook" phones on the same line remain at a low capacitance relative to the off hook circuit. This dynamic capacitance feature is acceptable and compatible with existing applications, since the primary need for the enhanced DSL stop band corresponds to the off hook phone, and

the presence of the phone's polarity guard diode bridge. The DSL high-level up stream energy can over-drive this diode bridge in the off hook phones, and accordingly produce unwanted inter-modulation distortion. Therefore, enhanced DSL stop band is needed to prevent such over-drive condition. When the phone or other extension device is on hook, the diode bridge is removed from the circuit, and less filter DSL stop band attenuation is required. Very little capacitance can therefore be employed in the filter circuits associated with the on hook phones. This allows the off hook phone to have a comparatively larger capacitance, and thus the dynamic filter can have near splitter performance.

Additionally, the filter and splitter circuits of the present invention includes a novel impedance correction circuitry on the line side of the circuit in order to further improve the voice band return loss and the phone's side tone, and therefore support prevailing European telecommunications standards and objectives.

Filter Circuit Description

Referring now to Fig. 2, a first embodiment of the dynamic micro-filter configuration of the invention is described. It will be appreciated that while the embodiment of Fig. 2 comprises an exemplary design adapted to meet the requirements for use in the United Kingdom (UK), the dynamic filter of the present invention may be adapted for use in literally any application, such as that of Fig. 3 herein (adapted for use in Sweden), or other countries, through proper component selection and configuration. Such alternate applications and adaptations are readily determinable to those of ordinary skill based on the present disclosure, and accordingly are not described further herein.

It will further be appreciated that while the following discussion is cast in terms of a plurality of discrete electrical components (i.e., resistors, inductors, capacitors, switches, etc.) used to form a circuit, portions of the circuit may be rendered in the form of integrated components (such as integrated circuits) or other types of components having the desired functionality and electrical performance.

As shown in Fig.2, the filter circuit 200 generally comprises an input section 202 having a plurality of input terminals (line side jack) 204 and two input inductors 206, 208. An output section 220 comprises two additional inductors 224, 226 (L3 , L4) and three capacitors 227, 228, 230 (C4, C9, C6). The filter's input inductors (L1, L2) 206, 208 are connected to the line side jack 204, while the filter's capacitive output section 220 is connected to the filter's phone side jack 240. The line and phone side jacks 204, 240 a UK-type modular jack of the type commonly used in the United Kingdom, although it will be

recognized that other types of modular plugs and connectors may be substituted. The filter 200 further includes a DSL jack 250 that, in the illustrated embodiment, comprises and RJ-11 type DSL jack, although others may be substituted as well. The DSL jack 250 passes directly via electrical pathways 252 to the line side jack 204 (or plug) to provide a convenience DSL or home phone network (HPN) jack.

The basic filter provided by the circuit of Fig. 2 is a fourth-order elliptical low pass filter that consists of the two input inductors 206, 208 (L1, L2), two output section inductors 224, 226 (L3, L4), and three bridge capacitors 227, 228, 230 (C4, C9, and C6, respectively). The input inductors 206, 208 provide the required input inductance to prevent loading on the DSL circuit, while the two capacitors 234, 236 (C1, C7) in the output section 220 are added to the output inductors 224, 226 (L3, L4) to produce a resonance on the order of 30 KHz, although it will be appreciated that other resistance and capacitance values can be selected in order to obtain other resonance frequencies. Accordingly, the embodiment of Fig. 2 is a fourth-order elliptical filter which produces a sharp 30 KHz cut-off. The elliptical stop band feature allows the design to minimize the total capacitance to typically < 40 nF (i.e., < 40E-09 Farad), which minimizes the effect of the capacitance on the phone's voice band performance.

Dynamic Components

To make the filter 200 dynamic and allow for self-installation by the subscriber for multiple filters for each telephone, two reed switches 262, 264 (K1, K2) are added to remove most of the filter capacitance for the on hook (idle) phones. Both of the reed switches 262, 264 are, in the embodiment of Fig. 2, magnetically coupled to the dual inductor 270 (L5A), as described in U.S. Patent Nos. 6,181,777 and 6,212,259 entitled "Impedance Blocking Filter Circuit", issued January 30, 2001 and April 3, 2001, respectively, and assigned to Assignee hereof. Specifically, the reed switches 262, 264 are coupled to the dual inductor 270 by virtue of their physical proximity to the windings of the inductor, and therefore the magnetic field generated thereby.

Figs. 2a and 2b illustrate one exemplary configuration for a dual inductor/reed switch device 266 compatible with the circuit of Fig. 2 and incorporating the dual inductor 270 and reed switches 262, 264. The inductor/reed switch device 266 is formed of cylindrical housing 267 and contains the dual inductor 270 and the two reed switches 262, 264. It should be apparent to those skilled in the art that the dual inductor/reed switch device 266 can be replaced with two single inductor/switch units (not shown) so as to

render the same functionality. In the illustrated embodiment, the reed switches 262, 264 are disposed horizontally with their longitudinal axis substantially parallel with that of the bobbin 268. This configuration provides the aforementioned magnetic coupling between the windings of the inductor 270 and the switches to operate the latter. The device 266 of Figs. 2a-2b is selected to be actuated on a predetermined loop current threshold (e.g., approximately 6-16 mA). If the loop current threshold is too low, the reed switch(es) may chatter during operation of the circuit, and may thus shorten the useful life of the switch(es). On the other hand, if the loop current threshold is too high, then the amount of loop current may be insufficient to actuate the switch(es) in the worst case condition.

Figs. 2c and 2d illustrate a second embodiment of a dual winding inductor/reed switch device 266 according to the invention. In this embodiment, the reed switches 262, 264 are disposed centrally within the interior region of the windings. It will be appreciated to those of ordinary skill in the magnetic component arts that any number of different physical configurations for the dual inductor/reed switches may be used consistent with the circuit of Fig. 2. The foregoing embodiments are therefore merely illustrative of the broader concepts.

When no loop current flows (because the phone is on hook), there is no magnetic field from the dual inductor 270 and the reed switches 262, 264 are open, which removes the capacitors 227, 230 (C4 and C6) from the circuit. This reduces the total capacitance for each on hook filter from approximately 37.7 nF to only 4.7 nF in this embodiment. The 4.7nF value is the minimum capacitance necessary to force any on hook phone resonance below 30 KHz. Additionally, to protect the reed switches 262, 264 from the ringing voltage, power cross-voltages and lightning induced transient voltages, two Zener diodes 276, 278 (D1, D2) are included across the reed switches 262, 264 as shown in Fig. 2 to clamp the peak voltage to below 12 V. The single diodes 276, 278 of the illustrated embodiment work satisfactorily because the capacitors are in series with the diodes, and will self bias the single diode when AC signals are present. Alternatively, however, the foregoing diode arrangement may be replaced dual back-to-back 6-12 V Zener diodes, or even low capacitance varistors. The construction and selection of such components, consistent with the present aims of providing the minimum capacitance in the device, are well known in the electronics arts, and accordingly are not described further herein.

To protect the reed switches 262, 264 from switching current spikes through the C9 capacitor 228 and the C4 capacitor 227 (and the C1, C7 capacitors 234, 236) when the reed switches close, two resistors 280, 282 (R5, R6) are added in series with the C4 and C6

capacitors 226, 230 to limit the switching current to below the maximum current ratings of the switches. The resistance values of R5, R6 are chosen low enough so as not to significantly affect the filters stop band performance.

Impedance Correction

The foregoing dynamic components of the filter 200 are collectively insufficient to provide enough return loss improvement to meet the requirements of the European/UK Specifications previously described. To address this issue, the resonant impedance correction circuit made from the dual inductor 270 (L5A, L5B), parallel network capacitors 290, 292 (C2, C3), and parallel network resistors 294, 296 (R4, and R1) further improves the voice band return loss up to 10 db by adding a positive phase impendence in the 2-3 KHz band. The dual inductor 270 (L5A, L5B) performs a dual purpose; in addition to driving the reed switches during off hook as previously described, the dual inductor 270 (in combination with the network capacitors C2, C3 290, 292) forms a differential resonance impedance in series with the line input. The parallel network resistors 294, 296 (R3, R4) limit this impedance to approximately 200 ohms at resonance, which limits the maximum insertion loss to an acceptable level (i.e., on the order of 2 db).

The circuit 200 of Fig. 2 is further provided with a 1 microfarad ringing capacitor 291 (C10) across pins 4 and 5 of the phone jack 240. Filters used in UK applications require such a capacitor for ringing some three-wire phone installations. It will be recognized, however, that this capacitor is optional depending on the particular application in which the filter circuit of the invention is used.

It is further noted that the circuit 200 embodiment of Fig. 2 advantageously uses separate inductive coils for the various circuit inductors 206, 208, 224, 226 (L1, L2, L3, L4) rather than, for example, the dual EP13 style inductor typically used in many prior art designs. This arrangement provides a longitudinal blocking impedance as well as differential impedances, which some applications (including for example, European telecommunications specifications) require. Traditional EP-based designs have effectively no longitudinal impedance, so an additional coil is required. The additional coil adds extra DC resistance, and to compensate for the added resistance, larger coils are often required, thereby increasing the cost and space requirements associated with the filter. In contrast, with the separate coils design of the present invention, it is not necessary to add a longitudinal coil or increase the size of the filter's inductors. In the illustrated embodiment, the dual bobbin, dual shielded inductors such as those manufactured by the Assignee hereof

can provide the aforementioned longitudinal impedance as well as providing magnetic field to drive the reed switches. The construction and operation of these dual bobbin, dual inductors is described in detail in the aforementioned application and as specifically set forth in preceding sections of this application. It will be recognized, however, that inductors/impedances other than the dual bobbin, dual shielded type previously referenced may be used with success in the circuit 200 of Fig. 2. For example, the aforementioned EP-type inductors could be substituted; however, the attendant disadvantages of added coil, DC resistance, and inductor coil size would be present.

Referring now to Fig. 3, a second embodiment of the improved micro-filter apparatus of the present invention is described. This second embodiment 300 is particularly useful in single splitter application also having master jack wiring, such as is currently in use in Sweden. As shown in Fig. 3, the line jacks 302 and phone jack 304 are configured to interface with the two-wire systems of Sweden (in contrast to the four-wire variants in the UK as embodied in the circuit 200 of Fig. 2). The 1 microfarad ringing capacitor 291 (C10) across pins 4 and 5 of the UK phone jack is also obviated in the present embodiment. Additionally, in the embodiment of Fig. 3, the reeds 262, 264 and diodes 276, 278 of the circuit 200 of Fig. 2 are removed and replaced with short circuits 306, 308. The non-dynamic filter 300 functions as a splitter, and is simply plugged into the master jack located in the house or other installation site as a self-install splitter. As previously described with respect to Fig. 2, the impedance correction portion 320 of the circuit produces a splitter with superior return loss performance.

Housing

Referring now to Figs. 4a-4c, one embodiment of a filter housing adapted to receive the filter or splitter circuits 200, 300 of the present invention is described. The housing 400 comprises a polymeric base plate 402 (such as ABS plastic) and cover 404 which collectively form a cavity (not shown) within which the filter/splitter circuit 200, 300 is received. The circuit is disposed on a circuit board 403 received in the cavity and restrained by the base plate 402 and cover 404 when the housing is assembled. In the illustrated embodiment (adapted for UK installation), the housing 400 further includes a two- or four-terminal line side plug or jack 204, two or four-terminal phone side plug or jack 240, and RJ-11 DSL jack 250 disposed within respective apertures 410, 412, 414 formed in the front and rear sides 422, 424 of the housing cover 404. In the case of the circuit 300 of Fig. 3, the four-terminal jacks 204, 240 would be replaced with two-terminal jacks. Alternatively, the housing (and associated

filter/splitter circuit) could be configured with three RJ-11 jacks, two RJ-45 jacks and an RJ-11 DSL jack, or any number of other permutations apparent to those of ordinary skill.

The housing can be mounted in literally any orientation and configuration desired including, for example, as a wall-mounted unit, or as a "free floating" (i.e., un-mounted) in-line unit. It will further be recognized that the housing (and filter circuit) may be adapted as other configurations, such as dual jack housings, cord and multiple jack housings, or cord and single jack housings. The housings and/or filter/splitter circuits may be ganged as well. Additionally, other signal conditioning devices may be incorporated within the housing (whether electrically or physically interfaced with the aforementioned circuits or otherwise) if so desired, consistent with electrical noise and physical space limitations.

System

Referring now to Fig. 5, a telecommunications architecture employing the filter(s) previously described herein is disclosed. As shown in Fig. 5, the improved architecture 500 comprises (i) a telecommunications line 502 adapted for carrying DSL and voice signals to one or more distant ends 504; (ii) a local (site) telecommunications infrastructure 506 comprising a plurality of extensions (jacks) 508 accessible by the subscriber; (iii) a plurality of filter (or splitter) circuits 501 electrically interfaced with respective ones of the jacks 508; and (iv) a plurality of extension devices 510 electrically interfaced with respective ones of the filter circuits 501. The illustrated extension devices 510 comprise a standard telephone 510a, telephone with answering machine 510b, facsimile machine 510c, personal computer (PC) 510d with DSL modulator/demodulator apparatus 540, and wireless interface 510e, although other types of devices and combinations may be used. The individual filter circuits 501 are housed in respective housings of the type shown in Fig. 4 herein, and are made self-installable by the subscriber, such as through use of modular jack connections between the extension jacks 508, filter circuits 501, and extension devices 510.

As previously described, in the case of the dynamic filter circuit 200 of Fig. 2, an off hook condition present on one of the extension devices 510a-c generates a loop current which alters the reed switch position, thereby elevating the effective capacitance seen at the telecommunications extension jack 508 associated with that extension device. This advantageously permits the off hook filter circuit to have near splitter performance.

It is also noted that for a non-master jack facility or home, distributed dynamic filters may be utilized.

While the above detailed description has shown, described, and pointed out novel features of the invention as applied to various embodiments, it will be understood that various omissions, substitutions, and changes in the form and details of the device or process illustrated may be made by those skilled in the art without departing from the invention. The foregoing description is of the best mode presently contemplated of carrying out the invention. This description is in no way meant to be limiting, but rather should be taken as illustrative of the general principles of the invention. The scope of the invention should be determined with reference to the claims.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. Telecommunications signal conditioning apparatus adapted to provide both enhanced stop band attenuation and enhanced voice band return loss performance, comprising:

first terminals adapted to interface with a first telecommunications line, said telecommunications line being adapted to carry signals having DSL and voice band components;

second terminals adapted to interface with an extension device;

impedance correction apparatus disposed electrically between said first and second terminals and adapted to alter return loss with respect to said voice band component of said signals;

signal filter apparatus in electrical communication with said first and second terminals and said impedance correction apparatus and comprising dynamic switching apparatus adapted to selectively alter the configuration of said signal filter apparatus so as to increase the capacitance of said filter apparatus, said increase in capacitance providing at least in part said enhanced stop band attenuation.

2. The apparatus of Claim 1, wherein said enhanced stop band attenuation is provided at least above 30KHz.

3. The apparatus of Claim 2 1, wherein said filter apparatus comprises a fourth order elliptical filter.

4. The apparatus of Claim 2, wherein said enhanced return loss performance comprises return loss of at least 10db.

5. The apparatus of Claim 1, wherein said dynamic switching apparatus comprises a plurality of reed switches magnetically coupled to at least one circuit element within said signal filter apparatus.

6. The apparatus of Claim 1, wherein said increasing the capacitance of said signal filter apparatus is determined at least in part in response to electrical current flowing in said signal filter apparatus.

7. The apparatus of Claim 6, wherein said increasing the capacitance of said signal filter apparatus comprises increasing the capacitance of said filter apparatus to a value significantly greater in magnitude than that of other extension devices in communication with said telephone line.

8. The apparatus of any Claims 6 or 7, wherein said filter apparatus comprises a fourth order elliptical filter.

9. The apparatus of Claim 1, further comprising voltage protection apparatus, said protection apparatus being adapted to protect said dynamic switching apparatus

from voltage transients present within said telecommunications signal conditioning apparatus.

10. The apparatus of Claim 9, wherein said voltage protection apparatus comprises a plurality of Zener diodes disposed in electrical parallel with respective ones of said dynamic switching apparatus.

11. The apparatus of Claim 1, wherein said impedance correction apparatus comprises at least one RLC parallel network.

12. The apparatus of Claim 11, wherein said at least one RLC network is adapted to generate a positive phase impedance in a predetermined signal band.

13. The apparatus of Claim 12, wherein said predetermined signal band comprises approximately 2-3 KHz.

14. The apparatus of Claim 1, further comprising a third set of terminals, said third set of terminals being in electrical communication with said first set of terminals and adapted to interface with a second telecommunications line, said second line being in data communication with an xDSL modulator/demodulator apparatus.

15. The apparatus of Claim 1, wherein said signal filter apparatus comprises a plurality of inductors, each of said inductors having a respective coil.

16. The apparatus of Claim 1, wherein said signal filter apparatus comprises a plurality of dual bobbin magnetically shielded inductors.

17. A method of conditioning a digital subscriber line (DSL) signal flowing through filter circuit so as to provide both at least predetermined minimum levels of stop band attenuation above a predetermined frequency, and voice band return loss greater than a predetermined minimum value, comprising:

filtering at least a portion of said signal;

switching at least a portion of said filter circuit, said act of switching selectively altering the configuration of said filter circuit so as to increase the capacitance thereof, said increase in capacitance providing at least in part said minimum level of stop band attenuation stop band attenuation; and

selectively adjusting the impedance of said circuit to provide said return loss greater than said minimum value.

18. The method of Claim 17, wherein said frequency comprises 30kHz.

19. The method of Claim 17, wherein said increase of the capacitance comprises dynamically varying the capacitance based on the magnitude of current flowing through at least a portion of said circuit.

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20. The method of Claim 19, wherein said act of dynamically varying comprises selectively opening and closing a plurality of switch elements disposed within said circuit.

21. The method of Claim 18, wherein said act of filtering comprises filtering said DSL signal using a fourth-order elliptical filter.

22. The method of Claim 17, wherein said act of adjusting the impedance comprises generating a positive phase impedance in a predetermined signal band.

23. The method of Claim 22, wherein said act of generating comprises generating a said positive phase impedance in the 2-3 KHz signal band.

24. The method of Claim 17, wherein said minimum value of return loss comprises 10db.

25. The method of Claim 17, wherein said acts of selectively adjusting the impedance and increasing the capacitance cooperate to produce at least a 30 KHz stop band and positive phase impedance in a predetermined frequency range.

26. The method of Claim 24 or 25, wherein said act of filtering comprises filtering said signal using a fourth order elliptical filter.

27. Signal splitter apparatus for use with telecommunications signals having at least first and second signal components, comprising:

filter apparatus having a plurality of inductors and being adapted to filter said telecommunications signals; and

impedance correction tank circuits in electrical communication with said input filter apparatus and adapted to control the return loss associated with said second component of said signals;

wherein at least first and second ones of said plurality of inductors are disposed before and after, respectively, said impedance correction tank circuits, within said splitter apparatus.

28. The signal splitter apparatus of Claim 27, wherein said filter apparatus further comprises a plurality of capacitors arranged with said inductors so as to produce fourth-order elliptical filtering of said signals.

29. The signal splitter apparatus of Claims 27 or 28, wherein said impedance correction apparatus comprises at least one RLC parallel network.

30. The apparatus of Claim 29, wherein said at least one RLC network is adapted to generate a positive phase impedance in a predetermined signal band.

31. The apparatus of Claim 28, wherein said plurality of inductors and capacitors comprise four inductors and three capacitors respectively, two of said four capacitors being disposed in serial within each of two parallel electrical pathways

formed between line-side and extension-side terminals of said splitter apparatus, said three capacitors acting as bridge capacitors between said two electrical pathways.

32. The telecommunications signal conditioning apparatus of Claim 1, wherein said line further comprises a plurality of other extensions, said apparatus further comprising:

signal filter apparatus in electrical communication with said first and second terminals; and

dynamic switching apparatus in electrical communication with at least said signal filter apparatus, said dynamic switching apparatus being adapted to selectively alter the configuration of said signal filter apparatus in response to current flowing through said filter apparatus;

wherein said conditioning apparatus is configured such that an off hook condition existing in said extension device results in increased stop band performance with respect to said first component of said telecommunications signals.

33. The conditioning apparatus of Claim 32, wherein said signal filter apparatus comprises a fourth order elliptical filter.

34. A telecommunications subscriber-side system, comprising:

a telecommunications line adapted to carry signals having first and second signal components;

a plurality of signal conditioning circuits operatively coupled to said telecommunications line, each of said signal conditioning circuits having:

a filter circuit;

an impedance correction circuit adapted to provide increased return loss with respect to said second signal component; and

a dynamic switching circuit adapted to provide increased stop band loss attenuation with respect to said first component at least by increasing the capacitance associated with said filter circuit; and

a plurality of extension devices operatively coupled to said signal conditioning circuits.

35. The system of Claim 34, wherein said filter circuit comprises a fourth-order elliptical filter.

36. The system of Claim 35, wherein said impedance correction circuit comprises at least one RLC network disposed within said filter circuit.

37. A telecommunications subscriber-side system, comprising:

a telecommunications line adapted to carry signals having first and second signal components;

a plurality of signal splitter circuits operatively coupled to said telecommunications line, each of said splitter circuits having:

a greater-than-second-order filter circuit comprising both an input section and an output section;

an impedance correction circuit disposed electrically between said input and output sections and adapted to control the return loss with respect to said second signal component; and

a plurality of extension devices operatively coupled to said signal conditioning circuits, said extension devices operating on-hook at a low capacitance level relative to another of said extension devices operating at a higher capacitance when off-hook, said higher capacitance providing a minimum required stop band attenuation above a certain frequency.

38. The system of Claim 37, wherein said greater-than-second-order filter circuit comprises a fourth-order elliptical filter, and said impedance correction circuit comprises at least one RLC network disposed within said filter circuit.

39. The signal conditioning apparatus of Claim 1, further comprising an input section and an output section, wherein said input section and said output section are electrically coupled to said first and second terminals, respectively, said input section further being electrically coupled to said impedance correction apparatus, said output section further being electrically coupled to said impedance correction apparatus.

40. The signal conditioning apparatus of Claim 39, wherein said input section, impedance correction apparatus, and said output section are arranged electrically in that order between said first and second terminals.

41. The signal conditioning apparatus of Claim 39, wherein said input section comprises at least first and second inductors, and said output section comprises second and third inductors each in electrical parallel with respective resistors.

42. The signal conditioning apparatus of Claim 39, wherein said impedance correction apparatus comprises first and second tank (RLC) circuits disposed in electrical parallel with one another.

43. The signal conditioning apparatus of Claim 39 or 42, wherein said impedance correction circuit further includes a first reed switch, and said output section further includes a second reed switch, at least one of said first and second reed switches being adapted to selectively switch in and out a respective capacitor associated therewith during a hook-state change.

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44. The signal conditioning apparatus of Claim 43, further comprising at least first and second diodes disposed in electrical parallel with respective ones of said first and second reed switches.

45. The signal conditioning apparatus of Claim 44, wherein at least one of said at least first and second diodes comprises a back-to-back Zener diode arrangement.

46. The signal conditioning apparatus of Claim 43, further comprising an electrical resistance placed in series with at least one of said reed switches.

47. The signal conditioning apparatus of Claim 39 or 40, wherein at least one of said input and output sections cooperate with said impedance correction apparatus to produce at least a 30 KHz stop band and positive phase impedance in a predetermined frequency range.

48. The signal conditioning apparatus of Claim 39 or 40, wherein at least one of said input and output sections cooperate with said impedance correction apparatus to produce at least (i) a 30 KHz stop band, and (ii) significantly elevated off-hook capacitance as compared to other extension devices on said telephone line.

49. Telecommunications signal conditioning apparatus, comprising:

first terminals adapted to interface with a first telecommunications line, said telecommunications line being adapted to carry signals having first and second components;

second terminals adapted to interface with an extension device; and

impedance correction apparatus in electrical communication with said first terminals and adapted to enhance return loss with respect to said second component of said signals, said impedance correction apparatus comprising:

first and second inductors disposed in a dual inductor device configuration;

a plurality of capacitances and resistances disposed in electrical parallel with said first and second inductors; and

a reed switch operatively coupled to said inductor device;

wherein said dual inductor is adapted to both (i) drive said reed switch during off-hook conditions, and (ii) form a differential resonance impedance in series with the line input, said resistances being configured to limit the maximum insertion loss associated with said signal conditioning apparatus.

50. A telecommunications signal conditioning apparatus substantially as described herein with reference to Figures 2 to 5 of the accompanying drawings.

51. A method of conditioning a digital subscriber line (DSL) signal substantially as described herein with reference to Figures 2 to 5 of the accompanying drawings.

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52. Signal splitter apparatus substantially as described herein with reference to Figures 2 to 5 of the accompanying drawings.

53. A telecommunications subscriber-side system substantially as described herein with reference to Figures 2 to 5 of the accompanying drawings.

54. The system of Claim 34, wherein said increased capacitance of said filter circuit of a given one of said signal conditioning circuits is provided when said extension device associated with said given one circuit goes off-hook, said increased capacitance being substantially greater than a capacitance of each of the other signal conditioning circuits whose associated extension devices are on-hook.

55. Telecommunications signal conditioning apparatus adapted to provide both enhanced stop band attenuation and enhanced voice band return loss performance, comprising:

first terminals adapted to interface with a first telecommunications line, said telecommunications line being adapted to carry signals having DSL and voice band components;

second terminals adapted to interface with an extension device;

signal filter apparatus comprising:

first inductors in electrical communication with respective ones of said first terminals;

second inductors in electrical communication with respective ones of said second terminals; and

dynamic switching apparatus disposed electrically between said first and second inductors and adapted to selectively alter the configuration of said signal filter apparatus so as to increase the capacitance of said filter apparatus, said increase in capacitance providing at least in part said enhanced stop band attenuation; and

at least one impedance correction tank circuit disposed electrically between said first and second inductors and adapted to alter return loss with respect to said voice band component of said signals.

56. The apparatus of Claim 55, wherein said enhanced stop band attenuation is provided at least above 30KHz.

57. The apparatus of Claim 55, wherein said filter apparatus comprises a fourth order elliptical filter.

58. The apparatus of Claim 56, wherein said enhanced return loss performance comprises return loss of at least 10db.

59. The apparatus of Claim 57, wherein said dynamic switching apparatus comprises a plurality of reed switches magnetically coupled to at least one circuit element within said signal filter apparatus.

60. The apparatus of Claim 55, further comprising voltage protection apparatus, said protection apparatus being adapted to protect said dynamic switching apparatus from voltage transients present within said telecommunications signal conditioning apparatus.

61. The apparatus of Claim 60, wherein said voltage protection apparatus comprises a plurality of Zener diodes disposed in electrical parallel with respective ones of said dynamic switching apparatus.

62. The apparatus of Claim 55, wherein said signal filter apparatus comprises a plurality of dual bobbin magnetically shielded inductors.

DATED this fourteenth day of October 2004

Excelsus Technologies, Inc.
Patent Attorneys for the Applicant:

F.B. RICE & CO.

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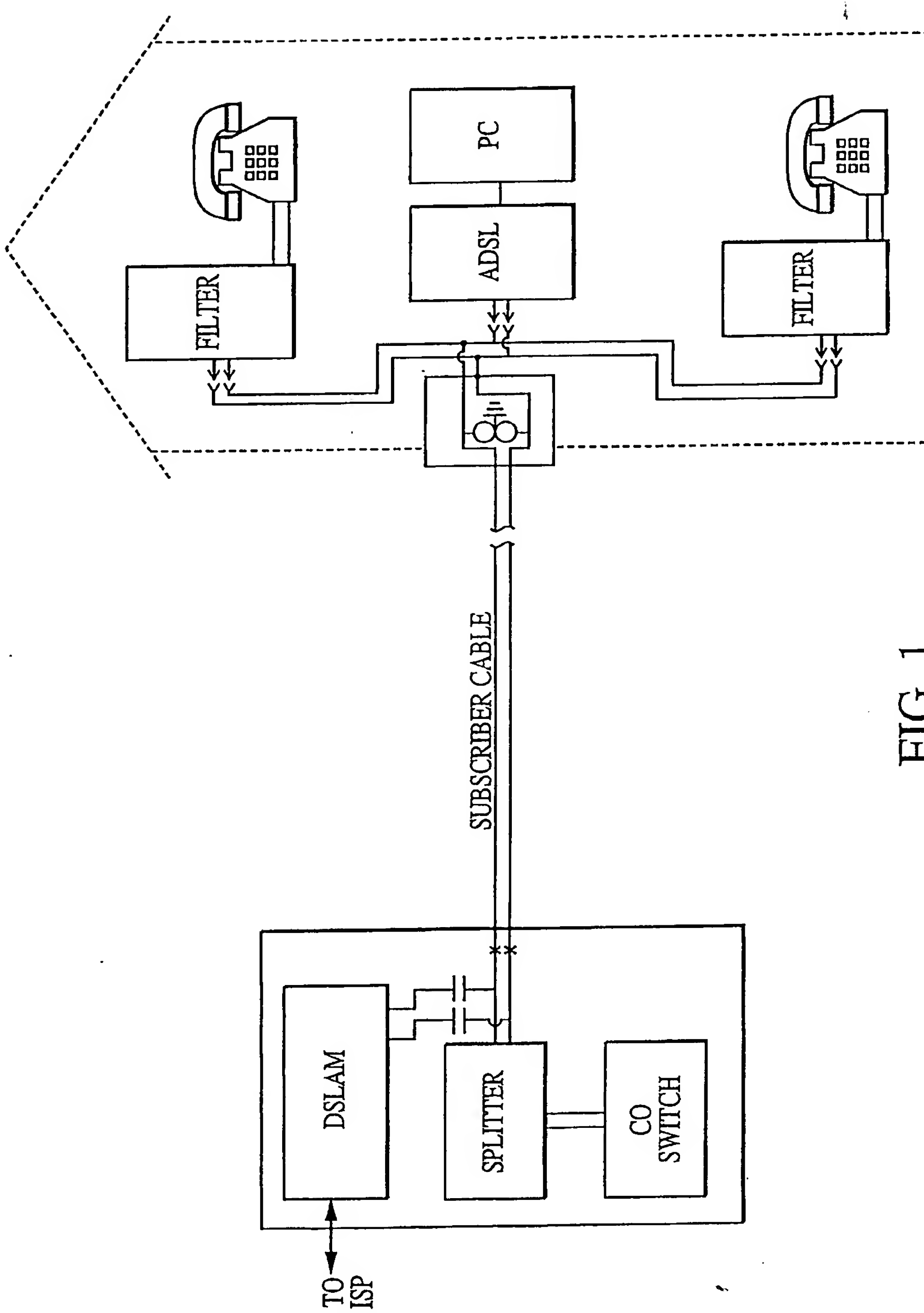


FIG. 1
PRIOR ART

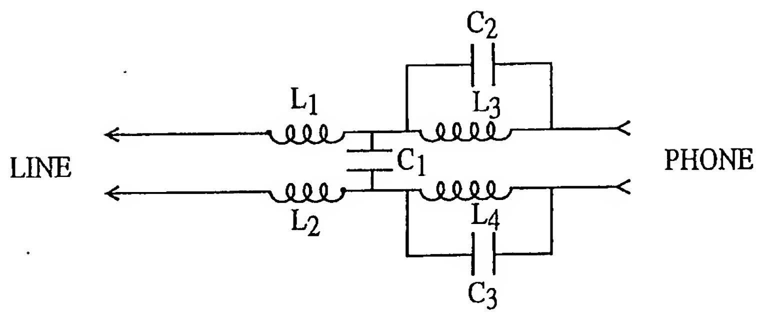
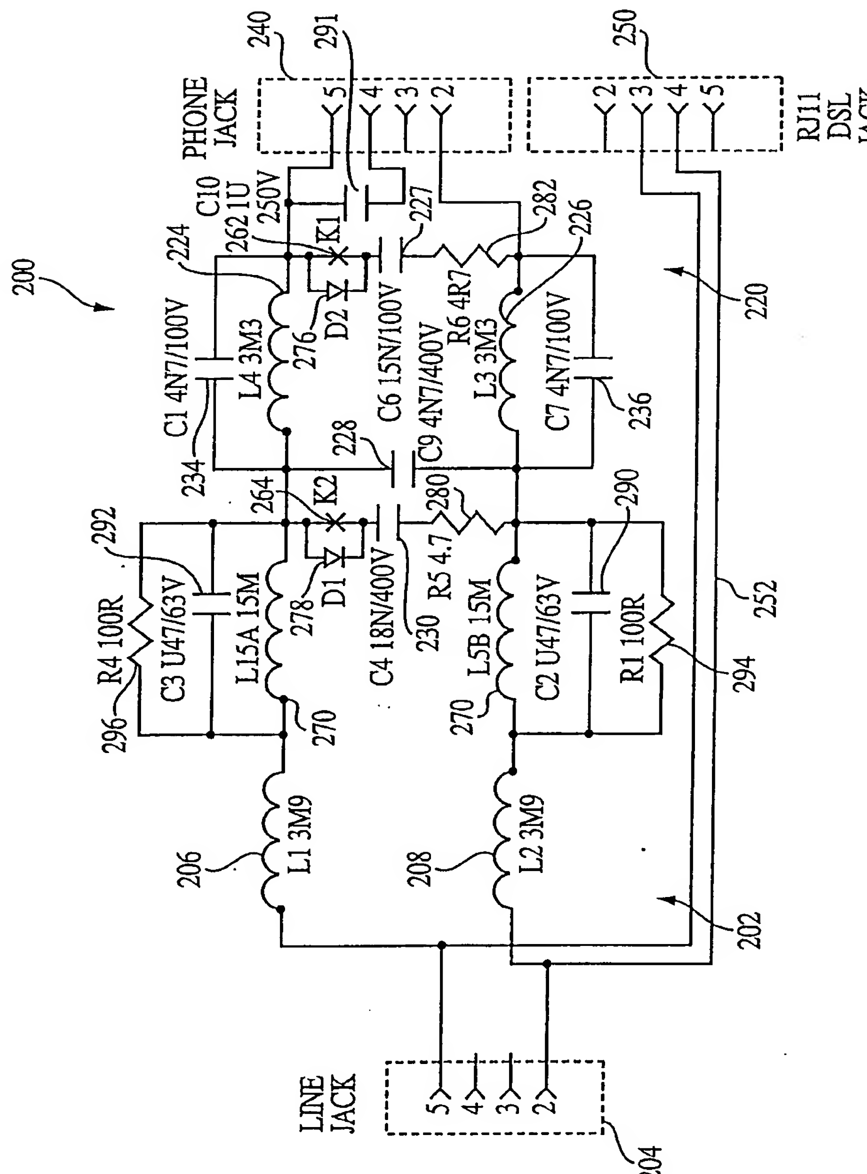


FIG. 1a
PRIOR ART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PHONE JACK
240
291
5
4
3
2
RJ11 DSL JACK
250
LINE JACK
204
C10 1U 250V
K1
262
227
282
226
224
C1 4N7/100V
234
L4 3M3
276
D2
C6 15N/100V
R6 4R7
C9 4N7/400V
L3 3M3
C7 4N7/100V
236
220
228
264
K2
280
R5 4.7
290
292
R4 100R
296
C3 U47/63V
L15A 15M
278
D1
C4 18N/400V
230
L5B 15M
C2 U47/63V
R1 100R
294
252
270
L1 3M9
206
L2 3M9
208
202

FIG. 2

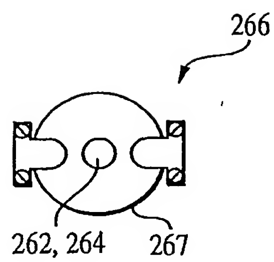


FIG. 2a

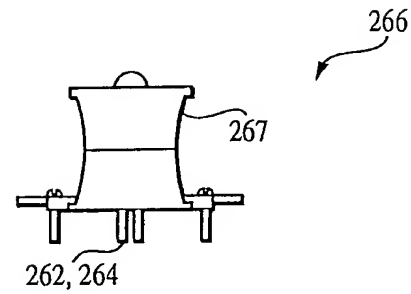


FIG. 2b

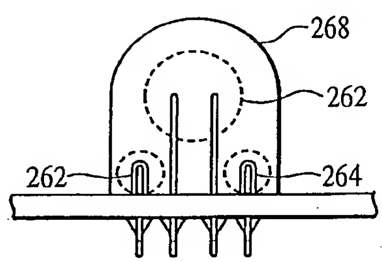


FIG. 2c

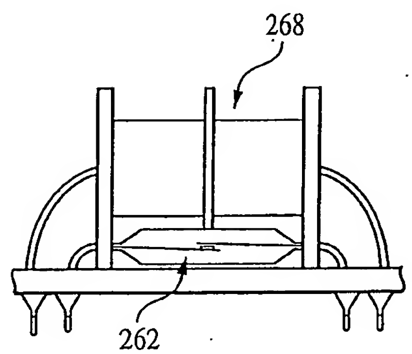
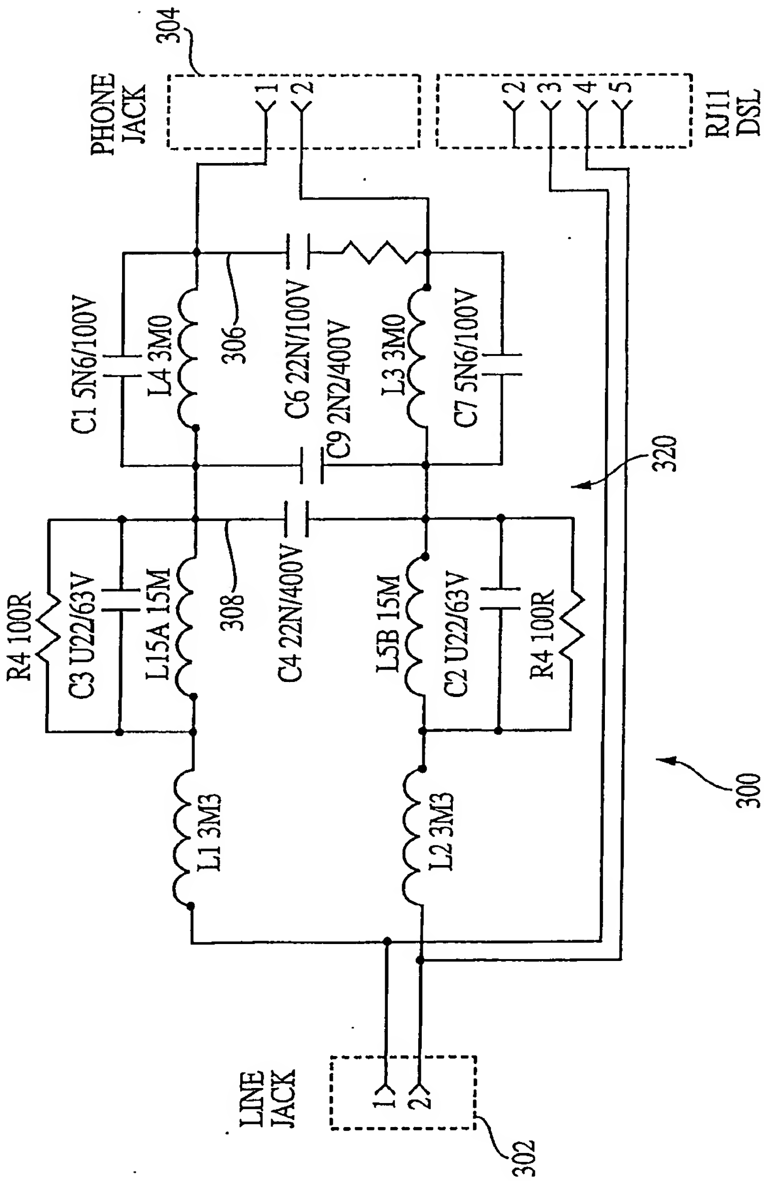


FIG. 2d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304
1
2
RJ11 DSL JACK
2
3
4
5
C1 5N6/100V
L4 3M0
306
C6 22N/100V
C9 2N2/400V
L3 3M0
C7 5N6/100V
320
R4 100R
C3 U22/63V
L15A 15M
308
C4 22N/400V
L5B 15M
C2 U22/63V
R4 100R
L1 3M3
L2 3M3
300
LINE JACK
1
2
302

FIG. 3

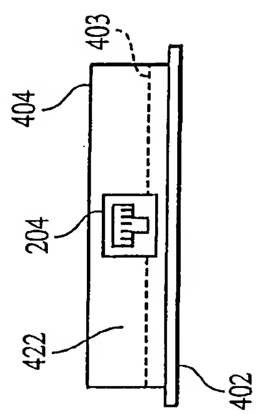


FIG. 4b

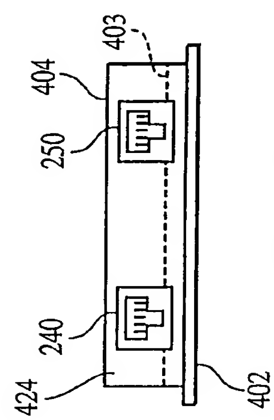


FIG. 4c

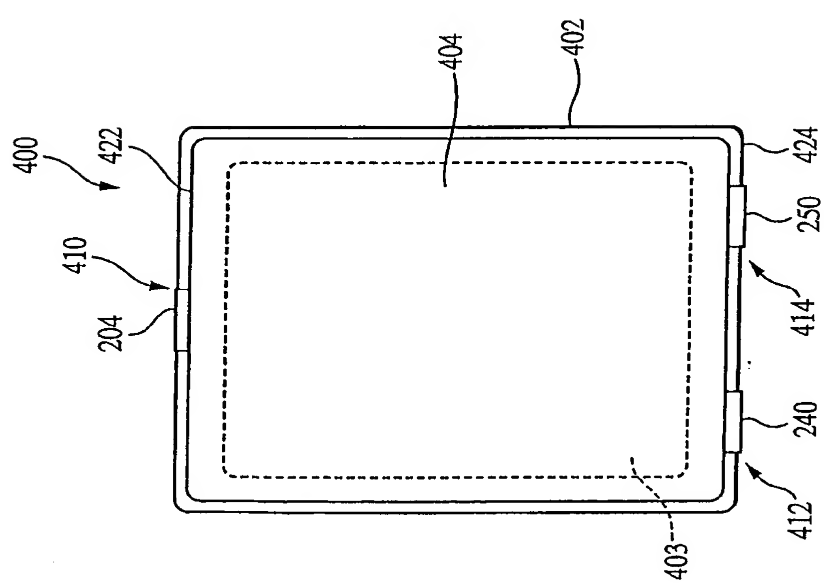
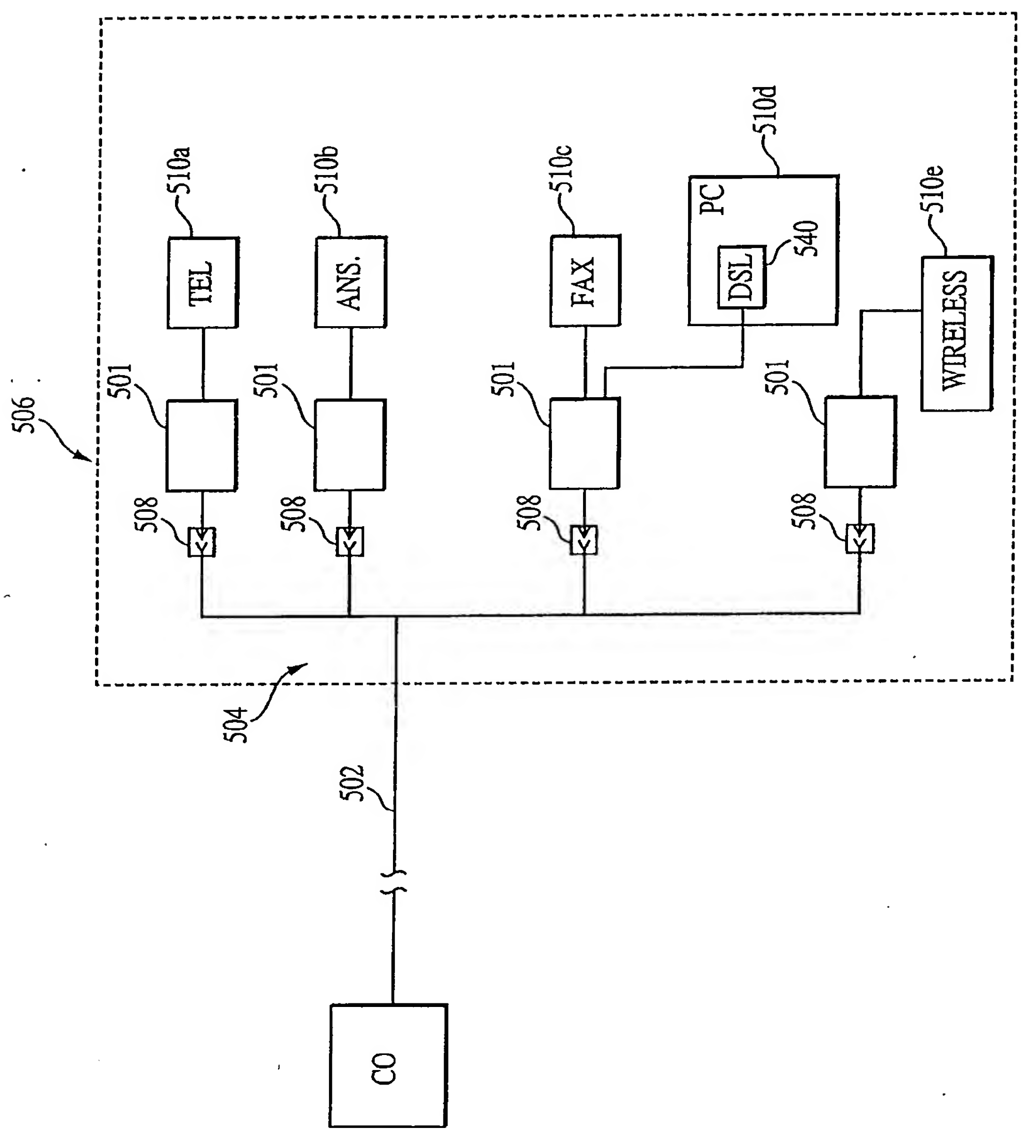


FIG. 4a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510b
510c
510d
510e
TEL
ANS.
FAX
PC
DSL
540
WIRELESS
501
501
501
501
508
508
508
508
506
504
502
CO

FIG. 5